DITCH CLEANING EXPERIMENTS IN DELAWARE

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Since the introduction of the dredge about 1885, many large systems of ditches and canals for drainage and irrigation have been built in the United States. The maintenance of these channels in efficient operating condition after construction is essential, if they are to continue to contribute to development and use of the land they serve. The demands of new construction work, however, seem to have mainly absorbed the attention of engineers and manufacturers of ditching machinery, and not much thought has been given to methods and equipment for maintenance work. Little has been done toward developing or adapting machinery to the special needs of repairing open channels and keeping them in operating condition, or in accumulating data on methods and costs of doing such work.

The purpose of this paper is to give a brief outline of ditch maintenance work being done in Delaware, to give costs of this and other channel cleaning work, and to briefly discuss machines now available for maintenance. Cost data on maintenance there should have wide application because there are many thousands of miles of open ditches once dradged and now considerably ineffective by reason of inadequate maintenance or no maintenance at all.

The legislature of Delaware appropriated $10,000 annually for two years to be used to improve and maintain drainage channels in Kent County. On September 28, 1931, the State Highway Depaerment and the U.S.D.A. Bureau of Agricultural Engineering signed an agreement providing that the two services should cooperate in carrying out the drainage work provided for by the state legislature.

In the past, landowners on individual watersheds in Delaware were organized for the purpose of collecting a ditch maintenance tax. Maintenance work was hand labor, supervised by overseers appointed by the organization from their own membership. An overseer would supervise a section about one mile long. During the last ten years an average of $100 to $150 per mile has been spent annually on some of the channels, but this has not provided adequate maintenance. The almost complete failure of all channels in this section of the state is a striking example of what may be expected on many projects if proper engineering supervision is not applied.

The program adopted and now being carried out by the state highway department and the federal bureau of agricultural engineering provides for a series of experiments to determine the costs of cleaning the ditches by different methods. Hand labor, teams and scoops, tractors and scoops, dynamite, and dredges are all being used, and accurate

determinations of costs are made for each job. After the channels are once properly repaired, a system of ditch patrol is to be established. A small fund has been reserved for chemical treatment to kill vegetation growing within and along the ditches.

Fig. 1 shows two typical channels in Kent County, Delaware. In this section trees, wild raspberries, wild blackberries, and green briers grow profusely along the channels. During the growing season these growths obstruct the ditches and greatly reduce their capacities.. Cleaning this vegetation away with hand labor is a slow and costly job which must be done every year. It is possible that chemical treatment will prove less costly and will greatly improve drainage conditions during the growing season.

Hand Labor. To determine the cost of hand labor in cleaning channels, a crew of eleven men, with a foreman experienced in handling ditch work, was employed for about four weeks. Men with shovels were paid 30 cents per hour, and the foreman 40 cents. This crew worked on three different sizes of channels. In a ditch having a top width of about 25 ft., bottom width of 10 ft. and a depth of 5 ft, the cost of removing silt was 83 ¢ per cubic yard of material taken out. On ditches having top widths of 6 to 10 ft. bottom widths of 1-1/2 to 4 ft. and depths of about 4 ft. the cost of removing silt was 40 cents per cubic yard.

Horses and Scoops. Although hand labor has been about the only method employed for cleaning ditches of all sizes in this county, some teams and scrapers have been used. For this work, inclines were cut in the side slopes every 300 ft. along the ditch. Teams enter at one incline, load the scrapers in the ditch, and pull out at the next incline up stream. Usually 3 to 5 teams work in a 300-ft. section. Small slip scrapers of 4 to 5 cubic feet capacity are used. To determine costs of this work, accurate cross-sections were made at short intervals through 1500 feet of channel. The ditch had a top width of 20 to 25 ft., bottom width of 10 ft. and depth of 5 ft. Men with teams that had previously been employed on this work were hired. A man with a team was paid 55 c per hr. Scoop stickers were paid 25 c per hr. and the foreman 40 c per hr. Five teams worked the greater part of the time. Two scoop stickers worked in the ditch and an experienced foreman supervised. This method of removing silt cost 62 c per cubic yard. Soil and channel conditions were almost identical with those where hand labor had cost 83 c per cubic yard.

A LOW INVESTMENT OUTFIT

Tractor and Scoops. A double drum winch was installed on a 35-hp tractor to drag skip scoops through the ditch. (See Fig. 2) A haul-back was arranged so that when one scoop was pulled from the channel another was pulled back into the ditch. For anchoring the haul-back line, three 4x6 fir posts were set 40 inches in the ground and 96 ft. apart on a line parallel to the ditch. Two pieces of 1/2-in. cable, each 96 ft. long,

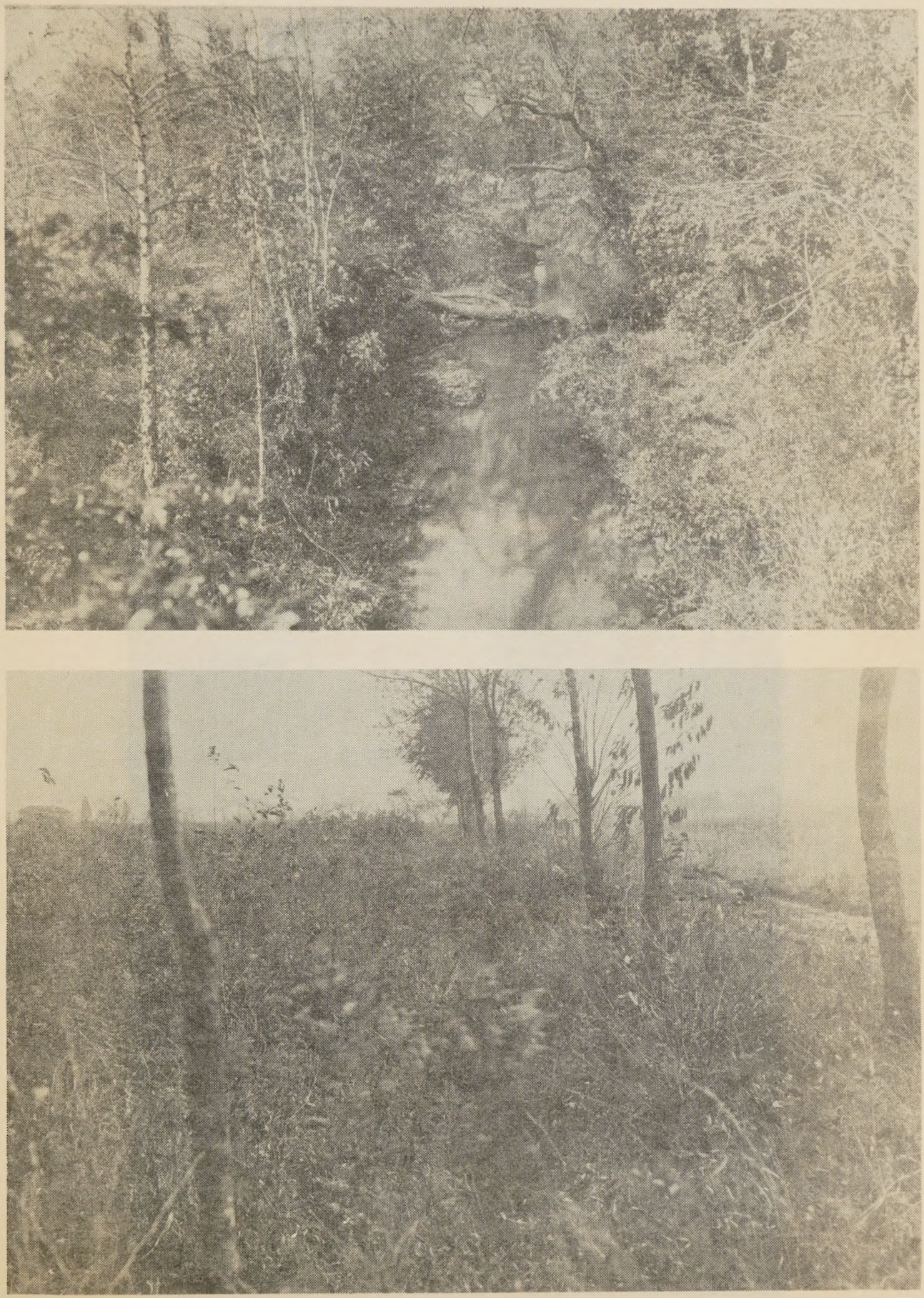
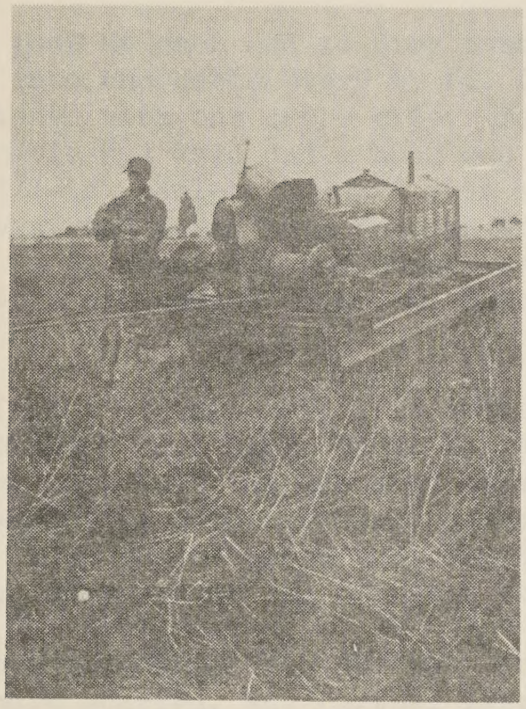
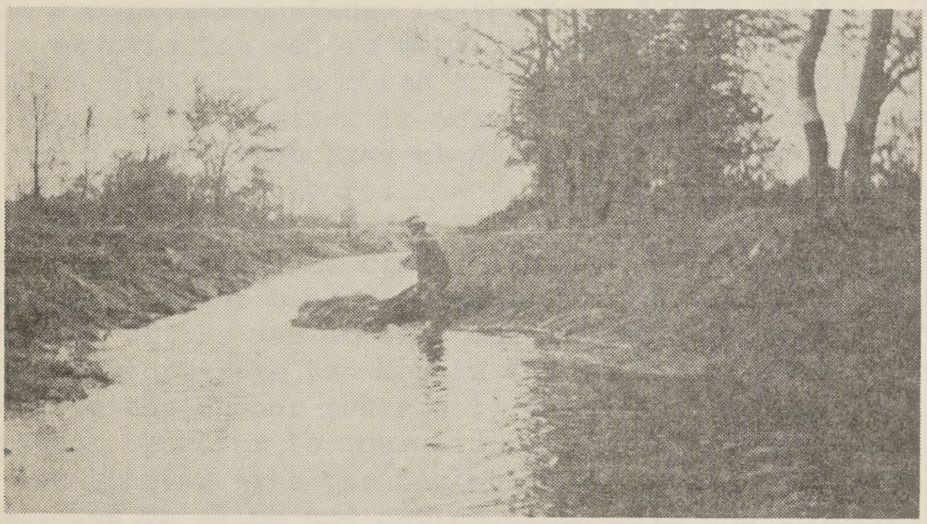


Fig. 1. Trees and briars quickly obstruct ditches in Kent County, Delaware, and have necessitated annual cleaning by hand labor. This has proven expensive and not entirely effective.





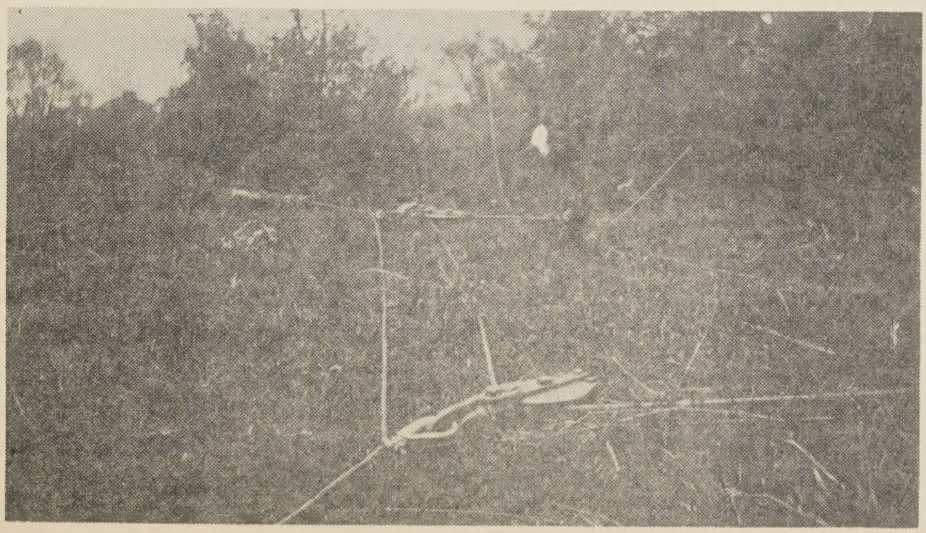


Fig. 2. (Top) Tractor with double winch. (Center) Loading scoop. (Bottom) Snatch block arrangement at anchor end of haulback for cleaning ditches with scoop and tractor.

were arranged with a loop at each end to drop over these posts. A 3/4-in. thimble was fastened into the cable every 12 ft. for hooking snatch blocks. Each thimble was fastened with one cable clip. For the drag cables on the winches 5/8-in. cable was used and a hook was fastened to the end of each drag cable. A 3/8-in. haul-back cable with a thimble in each end was fastened to these hooks, and taken back through the two 8-in. snatch blocks which were set 12 to 24 ft. apart on the anchor cable. To move along the ditch, the snatch blocks are unhooked and set further along the anchored cable.

The success of this of this method is quite dependent on obtaining proper scoops. Scoops must have large teeth so that they willload in hard clay and gravel. They must have long handles to make loading and dumping easier. They must be wide to make a good job of trimming. The distance from the back of the scoop to the hitch must be short so that the cutting edge can be held up to prevent cutting on steep banks.

We are still experimenting with scoops. Many improvements have been made since the work started, and further improvements are contemplated. The scoops are fastened to the drag cables with an 11-ft. lead cable. This permits the men to work up and down the ditch from the haul-backs and gives them time to place the scoop without stopping the tractor. The average speed of the winch is about 125 fpm. By using the short lead cable, the men in the ditch have about 11 sec. to place a scoop. Usually the snatch blocks are set 24 ft. apart, and the average section of ditch cleaned per set up is about 30 ft. long. Four men on the scoops, and the tractor operator comprise the crew. Two men stay in the ditch for loading, and two stay on the bank for dumping. The tractor operator acts as foreman, and one of the men on the bank assists him by signaling when it is necessary to stop. The two men in the ditch move the snatch blocks forward and keep the anchor posts set, while the two men on the bank assist the tractor operator to move his machine and the cables and to properly align the tractor with the haul-backs. A small tool box and magazine were mounted on skids and hauled along with the tractor.

Accurate cross-sectioning of this work showed that under most unfavorable conditions, the side slopes being covered with stumps and very irregular, excavation costs were about 26 c per cubic yard. In excavating quantities of about 15 cubic yards per 100 ft. per day can be cleaned by this method.

One advantage of this outfit in our work has been that it required very little initial investment. The state highway department owns the tractor and will use it in road work when the ditching is discontinued. The other advantages are that very little clearing outside the channel is required, for the cables and scoops can be operated between the trees. By using blocks, sufficient power is obtained to pull stumps and haul trees and logs from the ditches. Though dynamite is used to blast the large stumps, many of the small ones can be pulled with the tractor. These same features may prove an advantage to farmers having a tractor available for cleaning small farm ditches. Dynamite was used for rocks also, and often for heavy cuts where blasting was cheaper than scooping.

Blasting. Dynamite was first used to blast channels about 1897. Since then methods and materials have been greatly improved, and today it is generally recognized that explosives have a very definite place in both channel construction and channel maintenance. With the ditching dynamite now made, channels can be constructed of regular cross-section and true grade. In maintenence work, especially on large channels, conditions are very exceptional where dynamite is not considerably less expensive than hand labor.

In 1930, the E. I. du Pont de Nemours Company, the Ohio State University, and the U. S. Department of Agriculture cooperated in carrying out experiments in channel cleaning with explosives in northern Ohio. There most of the deposits in the channel were a fine clay. The experiments showed that 1-1/2 feet of material could be blown from the ditch for 25 to 35 cents per cubic yard. Where the depth was about 3 feet the material could be blasted for about 10 cents per cubic yard.

Dynamite is much more effective in clay than in sand. In Kent County, Delaware, sand is the prevailing soil, and all the work this far with dynamite has been experimental. Some very excellent results have been obtained by using about 1 to 1-1/2 lb dynamite per cubic yard of sand excavation.

The channel shown in Fig. 3 was cleaned with a single row of charges in the center of the ditch. Each charge contained 5 lb of explosive, and the charges were set 6 ft. apart and 34 in. deep to the bottom of the load.

One outstanding advantage of dynamite is the ease with which a large amount of potential power is transported. Where intermittent bars and collections of debris are to be removed, the use of explosives greatly simplifies the power-transportation problem. Spoil banks along a ditch often flourish with rank growths of vegetation and are always a cause of concern to the farmer. Explosives scatter the excavated material and leave no appreciable spoil banks.

The power of dynamite is easily wasted. Proper concentration of the charges and space-depth relationships will vary for different soils and with different moisture contents of a given soil. Some knowledge of these relationships is essential in order to obtain efficient results.

There is considerable need for experiments to determine where, when, and how to use explosives to the best advantage. Much useful information has been compiled by makers of explosives, but there is still a demand for information more thorough in detail and more comprehensive in scope, especially concerning loading methods for different classes of materials to be excavated.

Fig. 3. View both directions in a ditch before and after cleaning with dynamite. The soil was sandy, the work experimental, a single row of 5-lb charges was set 6 ft apart and 34 in deep to the bottom of the load.

As previously stated, dynamite has a very important place in any program or plan for efficient channel maintenance. Its use in the future will expand as more definite information is made available concerning the limits of its application as determined by efficiency, economy, and effectiveness.

Dredge Work. To compare costs of dredge work with other methods, a dredge with 1/2-yd. clam-shell bucket was rented for $33 per day, including operator, gas, and oil. This machine worked 9 days and the cost of the work was 10 c per cubic yard excavated. To the present there has been no work in a comparable section except by hand labor, which cost 84 c per cubic yard. This dredge made a cut 3 to 4 ft. deep with an average width of about 16 ft. Work of this type is more representative of construction costs than of maintenance costs.

Since the introduction of the dredge, much progress has been made in its development. Machines now on the market may be divided into three general classes - the suction dredge, the bucket or dipper dredge, and the elevator dredge.

The suction dredge has greatest application in river and harbor work, but seldom are conditions favorable for using it in agricultural drainage. It may be used to advantage where soil conditions are favorable and there is sufficient water.

Bucket or dipper dredges may use either the drag bucket, the grapple bucket, or the dipper. Some of them float in the ditch they are digging, some straddle it and run on a track placed along the ditch, and some are arranged with ingenious devices for lifting and throwing their weight along, or walking. Some excavating machines, particularly the older types, had to be dismounted in order to pass bridges, or to move from one job to another. The track-laying or apron-traction machines have largely overcome this disadvantage, and therefore are, in considerable degree, superseding the other types.

DREDGE DEVELOPMENT

The trend in development has been toward larger machines. For construction purposes this is desirable, but for maintenance purposes it is working in the wrong direction. With large machines, large quantities of material must be excavated in order to operate economically. To use a large, heavy machine for removing a few inches of silt and vegetation is not practical. Lack of a suitable light, low-cost excavator doubtless has been a considerable influence toward neglect of ditches until large amounts of material had badly congested them and made reconstruction necessary.

Very recently - even within the last two years - a number of small machines have been placed on the market. Most of these have buckets of about 3/8 yard capacity and booms up to about 30 ft. in length.

The need is for small bucket capacities, high traction speeds, and high digging speeds. Some improvements in bucket designs would also be desirable. Buckets for maintenance work may be lighter then those needed for construction work, because they do more dragging and trimming, and less digging.

The elevator dredge uses buckets mounted either on an endless chain or a revolving wheel. Of the two machines the endless chain type is adaptable to greater variations in channel sizes. It was designed in 1907 in the west and has been developed in that section for maintaining irrigation channels. It has a wide range of traction and digging speeds. As a general-purpose maintenance machine this type has superior features. Its adjustments for various sizes of channel and in traction and digging speeds are the very essential features required in maintenance work.

One disadvantage of the endless chain elevator machine is that on large ditches it must traverse both sides of the channel. In timbered sections this requires clearing of both banks. In sections where diversified farming is practiced, fences along the ditches interfere and moving these may be troublesome and costly.

SUMMARY

In recent years much improvement has been made in excavating machines suitable for the construction of open channels, and large investments have been made in systems of drainage and irrigation ditches. The life of open ditches, however, is very short in most soils unless they are kept reasonably free of sediment, debris, and vegetation.

The experiments in ditch maintenance work in Delaware have shown that such work performed by hand labor has been costing the landowners more than would have been required by other methods, in most instances. However, further investigation is necessary to determine the most economical methods of performing such work, and further experiments to determine the most suitable maintenance equipment.

Excavators with higher traction speeds would be desirable, and our work in Delaware indicates that lighter, wider, flatter buckets would be more effective in the removal of relatively small amounts of material and in obtaining a smooth ditch section. The equipment comprising tractor, cable and scoops has worked rather satisfactorily, and has the advantage of involving but rather little investment since it is not necessary to purchase the tractor just for this work.